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⑭発明の名称　真空槽内における基板交換機構

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明　細　書

1　発明の名称

真空槽内における基板交換機構

2　特許請求の範囲

(1)　側壁部に少なくとも2個の開口を有し、これをゲートバルブで開閉自在とした真空槽内に配設され、基板支持部を上下に少なくとも2段有する基板支持体と；該基板支持体を上下方向に所定の複数の位置で停止可能に駆動する昇降駆動部とから成り、前記2段のうち一方には表面処理済の基板を載置させ得るようにし、他方には未処理の基板を載置させ得るようにしたことを特徴とする真空槽内における基板交換機構。

(2)　前記2段のうち一方を冷却するようにしたことを特徴とする前記第1項に記載の基板交換機構。

(3)　前記2段のうち他方を加熱するようにしたことを特徴とする前記第1項に記載の基板交換機構。

(4)　前記両ゲートバルブのうち大気と連通、遮断を行うゲートバルブは前記真空槽の側壁部に設けられた通孔の真空室側の開口を、上向きに傾斜して設け、該開口を開閉する弁板を、真空隔壁を貫通して大気側に斜めに引き出されたロッドを介して、大気側に設置された駆動源によって昇降させるように構成したことを特徴とする前記第1項に記載の基板交換機構。

(5)　前記弁板は、基板の直径より大きく形成され、その両側部に取付けられ大気側に引き出された2本のロッドを介して、大気側に設置されたシリンダに連結されていることを特徴とする前記第4項に記載の基板交換機構。

3　発明の詳細な説明

〔産業上の利用分野〕

本発明は真空槽内における基板交換機構に関する。

〔従来の技術及びその問題点〕

第11図は従来の大気から真空槽内へのウェハーの取り込み機構の一例を示すが、図において本機構は大気からベルト搬送機（109）等の手段により

ゲートバルブもしくは仕切バルブ(104)を通って真空槽(101)内に送り込まれたウェハー(106)を真空槽(101)内に設けたベルト搬送機構(102)により槽(101)内の適当な位置まで取り込み、これを別に設けたウェハー上下機構によりベルト位置より上方に持ち上げ、次にウェハー(106)の下方に侵入した別のメカニズム上におろす機能を有する。

今、これを更に詳しく説明すれば以下の通りである。すなわち第11図Aに示すように、大気から仕切バルブ(104)を通過して真空槽(101)内に送り込まれた表面処理すべきウェハー(106)は、さらに真空槽(101)内に設けられたベルト搬送機構(102)により適当な位置まで運ばれ停止する。そこで仕切バルブ(104)が閉り、真空槽(101)内は真空に排気される。

次に第11図Bに示すように前記時点ではベルト(102)のウェハー(106)が乗る位置より下方に位置していたウェハー・プッシャー(108)がベローズ(105)を介して真空シールを保ったまゝウェハー上下駆動シリンダー(103)により上昇しベルト面より上方にウェハー(106)を持ち上げる。

しかる後に、ウェハー(106)の下方に別のウェハー搬送メカニズム(107)(例えばフォーク搬送のピックアップ等)がウェハー(106)の下方に侵入してくる。

次に第11図Cに示すようにウェハー・プッシャー(108)が下降し別のウェハー搬送メカニズム(107)上にウェハー(106)が受け渡される。

以上が大気側から真空槽(101)内へウェハー(106)を取り込む場合の動作であるが逆に処理済のウェハー(106)を大気側へ取り出す手順はこの逆となる。すなわち、上記従来例では、真空に排気されている真空槽(101)内へ、すでに処理の終ったウェハー(106)をメカニズム(7)により搬送し、その後、真空槽(101)をベントし、処理済ウェハー(106)をとり出す。さらに、未処理ウェハー(106)を真空槽(101)内に取り込み真空排気を行い、その後に、メカニズム(107)により、処理室へ搬送する。以上の大気⇔真空の排気サイクルを含むウェハーの取り出し、取り込み作業の間、処理室は、待時間となり、能率が悪い。

この問題を避けるためウェハー取り込み用真空槽と、ウェハー取り出し用真空槽を別々に設ける方法もよく用いられるが、この方法では装置の構成が複雑となる。

また真空槽を1つしか持たせない場合、装置のスループットにも因るが通常は大気⇔真空の排気サイクルを速くするため急速排気及び急速なベントが必要となるがLSIのパターンサイズが微細化している昨近、ウェハーへのパーティクル付着を極力抑えることが不可欠となっており、パーティクルの舞い上りをおこし易い真空槽内の急速な排気やベントは好ましくない。

〔発明が解決しようとする問題点〕

本発明は上記従来の種々の欠点を克服し、処理室において、前に取り込まれたウェハー(基板)を処理している間に次のウェハーを、真空槽内に取り込んでおき、さらに、真空排気を完了しておくことにより、処理室のウェハー交換作業から、ベント、排気に要する時間をはぶき処理室の待ち時間を減少させて生産性を向上する真空槽内における基板交換機構を提供することを目的とする。

〔問題点を解決するための手段〕

以上の目的は、側壁部に少なくとも2個の開口を有し、これをゲートバルブで開閉自在とした真空槽内に配設され、基板支持部を上下に少なくとも2段有する基板支持体と;該基板支持体を上下方向に所定の複数の位置で停止可能に駆動する昇降駆動部とから成り、前記2段のうち一方には表面処理済の基板を載置させ得るようにし、他方には未処理の基板を載置させ得るようにしたことを特徴とする真空槽内における基板交換機構によって達成される。

〔作　　用〕

上下2段の基板支持部のいずれか一方に未処理の基板を載置させているときに、他方に処理済の基板を載置させるのを真空状態で行ない、次いでこの状態で未処理の基板を所望の処理室へと搬出し、この後、真空槽内を大気圧にして、未処理の

基板を上記一方の基板支持部に搬入し、処理済の基板を大気中の所要の場所へと搬出する。次いで真空槽内を排気して上述の操作をくり返す。

以上の一連の作業のうち、真空槽内を大気圧にして未処理の基板を一方の基板支持部に搬入し、処理済の基板を大気中の所要の場所へと搬出し、さらに真空槽内を排気する作業は、先に処理室へ運ばれた未処理基板が、処理されている間に完了しておく。

〔実施例〕

以下、本発明の実施例によるCVD装置について図面を参照して説明する。

第1図は本装置(1)の全体を示すが、左右には一対のCVD反応室(2a)(2b)が設けられ、これらの間にバッファー室(3)が設けられている。バッファー室(3)と両反応室(2a)(2b)との間の隔壁にはゲートバルブ(4a)(4b)が設けられ、これらを介してウェハーの受け渡しが行われるようになっている。バッファー室(3)の前方には本発明に係わるウェハー交換室(5)が設けられ、ゲートバルブ(6)を介してこれら室(3)(5)間でウェハーの受け渡しが行われるようになっている。

バッファー室(3)内にはウェハー搬送機構(7)が設けられ、これは搬送用フォーク(8)を備え、矢印aで示すように中心軸(9)の回りに回動自在であり、かつ矢印bで示すように伸縮自在となっている。

ウェハー交換室(5)の両側壁部にもゲートバルブ(10)(11)が設けられ、この一方側には未処理ウェハー搬入用ベルト(12)が設けられ、ウェハーストック・カセット(13)から所定のタイミングで一枚宛、自動的に取り出してベルト(12)によりウェハー交換室(5)内に搬入するようになっている。また他方には処理済ウェハー搬出用ベルト(14)が設けられ、処理済ウェハーストック・カセット(15)へと搬入するようになっている。

次に第2図～第9図を参照してウェハー交換室(5)の詳細について説明する。

ウェハー交換室(5)は第2図に示すように密閉槽(20)によって画成され、上述したように両側壁部にゲートバルブ(10)(11)(第2図では図示省略)及び後壁部にゲートバルブ(6)を備えており、これらゲートバルブ(6)(10)(11)の詳細は後述するが、これらの開閉状態によって室(20)内は密封状態とされ、図示しない排気機構によって室(20)内は真空もしくは減圧状態におかれるようになっている。

室(20)内には第5図にその全体的形状が明示される基板支持体(21)が配設され、この底面には駆動軸(22)が固定され、これは密閉槽(20)の底壁部を気密に挿通して下方の大気中に延びておりスクリュー係合体(27)に固定されている。駆動軸(22)は真空シール(25)によって上下方向に気密に摺動自在に支承されている。

スクリュー係合体(27)はボールスクリュー(28)に螺合しており、このスクリュー(28)の下端部にはプーリ(29)が固定されている。モータ(31)は図示せずとも機枠に固定され、この回転軸に固定されたプーリ(32)と上述のプーリ(29)との間にベルト(30)が巻装されている。モータ(31)の回転によりボールスクリュー(28)が回転し、これによりスクリュー係合体(27)、従って駆動軸(22)は上方か下方へと移動する。モータ(31)は正逆回転自在であり、この回転方向に応じて駆動軸(22)は上方か下方へと移動する。スクリュー係合体(27)の一側方には高さセンサー装置(36)が設けられ、駆動軸(22)の各高さ位置がこれによって検知され、この検知信号によりモータ(31)は駆動制御される。

ボールスクリュー(28)は公知のようにねじ溝にボールを嵌めた構成となっており、駆動軸(22)をバックラッシュなく正確に所定の位置へ上昇又は下降させることができる。

スクリュー係合体(27)の小径部には冷却水入口及び出口が形成され、これに冷却水導入用チューブ(33)及び導出用チューブ(34)が接続されている。駆動軸(22)内には図示せずとも導入路及び導出路が形成され、基板支持体(21)の基部(37)内に蛇行状に形成される循環路(39)と連通している。なお、基板支持体(21)はアルミニウムから成り熱伝導性にすぐれている。

密閉槽(20)の3側壁部には上述のようにゲートバルブ(6)(10)(11)が配設され、これら側壁部に形成され

た開口(6a)(10a)(11a)を気密に閉じるように構成され、第1図では略図で示され、第2図ではゲートバルブ(6)については詳しく図示されている。

まず、ゲートバルブ(6)について第2図を参照して説明すると、これはすでに広く用いられている構造であって、主として開口(6a)を開閉するゲート本体(71)、これと平行リンク(73)(74)で結合された駆
から成り、部材(72)
動部材(72)の下端部分は真空シール(75)を介して大気に突出しておりシリンダ装置(76)によって上下に駆動されるようになっている。第2図ではゲート本体(71)が開口(6a)を閉じているが、駆動部材(72)を下降させるとゲート本体(71)は開口(6a)を開放し、これから駆動部材(72)を上昇させると第2図に示すように開口(6a)を閉じるようになっている。

次にゲートバルブ(10)(11)の詳細について説明するが、ゲートバルブ(10)(11)については同一の構成を有するので、ゲートバルブ(10)についてのみ第3図及び第4図を参照しにして以下、説明する。第3図はゲートバルブ(10)の作動状態を示す要部断面図であって、大気圧空間Aと真空室B（ウェハー交換室(5)）とを仕切る隔壁Cには、通孔(41)が穿設され該通孔(41)の真空室B側の開口(10a)は上向きに傾斜して形成されている。

上記開口(10a)には、その周りに形成された弁座部を開閉する弁板(43)が対向して設けられており、該弁板(43)は、ウェハー(47)の直径より大きく形成され、且つ上記通孔(41)を挿んでその両側に隔壁Cを貫通して斜め下方に延びる2本のロッド(44a)(44b)（第3図にはその一方が示されている。）を介して、大気圧空間Aの下方に設置された流体圧（油圧又は空気圧）駆動シリンダ(45)に連結されている。上記2本のロッド(44a)(44b)は、第4図に示すように、上端が弁板(43)の両側部のOリング(43a)より内側に取付けられ且つ、ロッドと弁板は、結合部から洩れないように溶接(43b)等でシールされている。また下端は、2本のロッドを連結する接続部材(44c)を介してシリンダ(45)のピストンロッド(46)に連結されている。なお、図中、(45a)(45b)はシリンダ(45)への圧力流体の供給又は排出導管、(42)(48)は大気圧空間A及び真空室Bにそれぞれ設置された搬送用ベルト(49)は軸受ブッシュ(50)はOリングを示す。

上記のように構成されているので、通常時、即ちウェハーを送り込まない時には、シリンダ(45)内で下方へ働く流体圧によって弁板(43)は、逆圧状態から通孔(10a)を経て開弁方向に圧力（大気圧）が働いている状態で、隔壁Cの通孔(10a)の真空室側開口(42)を密閉している。従って、真空室Bの真空は該通孔(10a)を経て洩れることはない。

次に、搬送用ベルト(42)によって大気圧空間Aより送られて来たウェハー(47)を、真空室Bへ移送するときは、シリンダ(45)の流体通路を切換えて、ロッド(44)(44a)(44b)を介して弁板(43)を上昇させ、開口(42)を解放する。この際、通孔(10a)は、2本のロッド(44a)と(44b)の中間部に位置しているので、ウェハー(47)の通過には支障はなく、該ウェハーは真空室Bへ円滑に移送される。

次いで、ウェハー(47)が真空室B内へ移行し終った段階で、再びシリンダ(45)の流路を切換えて弁板(43)を下降させ、開口(10a)を閉鎖する。なお、真空室B内へ移行されたウェハー(47)は搬送用ベルト(48)によって基板支持体(24)の所定の位置へ搬送される。

この実施例によれば、弁板を作動する駆動源が大気側に設けられており、また弁板作動のための摺動部がすべてウェハーより下方に位置されているので、該摺動部より生じるゴミ等がウェハー上に落ちる恐れは全くない。真空室も駆動源によって汚染されない。また、弁板とロッドが真空隔壁に対して傾斜して設けられているので、コンパクトに形成でき、両室におけるウェハーの両搬送用ベルトを互いに接近して設置できるので、装置がコンパクトになり、作業性もそれだけ向上する。なお、弁板は、圧力差に抗して逆圧状態で開口をシールすることになるので、十分な剛性をもった弁板と、十分な推力をもったシリンダ（駆動源）を選定する必要がある。

上記した実施例において、弁板の駆動源として流体圧駆動シリンダを用いた構造について説明したが、これに限らないことは勿論であり、機械的

駆動機構に代えることも可能である。

次に第5図～第9図を参照して蓋板支持体(20)の詳細について説明する。

蓋板支持体(20)の蓋板部(37)には、この上面より一段と低くなったフォーク受入れ用凹所(51)が形成され、これに連通して一対の溝(52a)(52b)が形成されている。第6図にはウェハー搬送用フォーク(8)の一部が図示されているが、このフォーク部(8a)(8b)が溝(52a)(52b)に挿通可能となっている。

溝(52a)(52b)の延在方向とは直角方向に蓋板支持体(20)のウェハー搬入側半部には全高にわたって一対の平行な切欠き(53a)(53b)が形成され、また、これらに整列してウェハー搬出側半部にも一対の平行な切欠き(54a)(54b)が形成されているが、第6図及び第8図に明示されるように一端部においては全高にわたっておらず連結部(55)によって覆われている。

切欠き(53a)(53b)(54a)(54b)とは上下方向に整列してベルトコンベヤ(56a)(56b)(57a)(57b)が配設され、これらは蓋板支持体(20)が上下するときに切欠き(53a)(53b)(54a)(54b)を遊通することができるようになっている。なお、ベルトコンベヤ(56a)(56b)は全体として第3図が示すベルトコンベヤ(48)を構成するものである。

蓋板支持体(20)の中央上部には部分的環状の上段蓋板支持部(58)及びこれより下方に位置して同心的に部分的円形状の下段蓋板支持部(59)が形成されている。上段蓋板支持部(58)は第6図に明示されるように円弧状の受面(58a)(58b)(58c)(58d)(58e)(58f)から成っており、これらは同一レベル上にあるが、第7図及び第8図で一点鎖線で示されているように、これらから成る上段蓋板支持部(58)上に未処理のウェハー(47)が載置されるようになっている。また下段蓋板支持部(59)は同一レベル上にあり各々、円の一部を構成する受面(59a)(59b)(59c)(59d)(59e)(59f)(59g)から成っており、やはり第7図及び第8図で一点鎖線で示されているように、これらには表面処理済のウェハー(47)'が載置されるようになっている。

蓋板部(37)の底面には円形の段孔凹所(60)が形成されているが、ここに上述の駆動軸(29)の上端部が嵌着され、図示せずともねじ等により固定されるようになっている。

以上は本実施例の構成について説明したが次に作用について説明する。

第10図A～Fは蓋板支持体(20)の各高さ位置を示しているが本実施例によれば蓋板支持体(20)は5つの高さ位置を取る事が出来る。尚、バッファ室(3)から伸縮するフォーク(8)のレベル及びベルトコンベヤ(56a)(56b)(57a)(57b)のレベルは一定である。第10図に於て蓋板支持体(20)の形状は簡略化して示されており、また上述したウェハーの上段支持部(58)及び下段支持部(59)は図面をわかりやすくする為にコ字状の上アーム上及び下アーム上としUまたはDでこれ等を示すものとする。（すなわちUとDとは上段支持部(58)と下段支持部(59)と等価である。）今、蓋板支持体(20)は第10図Aの高さ位置にあり未処理のウェハー(47)は上段支持部Uに載置されているものとする。また両側壁部のゲートバルブ(10)(11)は閉じているものとする。（ゲートバルブ(6)は開で真空状態にある）。この状態においてフォーク(8)はバッファ室(3)から伸びてきて処理済のウェハー(47)'を載置させて第10図Aに示すように上段支持部Uと下段支持部Dとの間に至る。

ここで蓋板支持体(20)は第10図Bで示す位置へと上昇する。この上昇途上において処理済のウェハー(47)'は下段支持部D上に載置されて、ここで停止し、尚、蓋板支持体(20)は上昇し第10図Bの位置で停止するのであるが、ここではフォーク(8)は処理済のウェハー(47)'から離れて図示の位置（溝(52a)(52b)内）にある。この位置においてフォーク(8)は矢印で示す如くバッファ室(3)へと後退する。

第10図Cに示すように蓋板支持体(20)は下降し再び第10図Aの高さと同じ位置を取る。ついで、フォーク(8)が第10図Cで矢印で示すようにバッファ室(3)からウェハー交換室(5)内に伸びてきて図示の位置を取る。蓋板支持体(20)は下方へと移動し第10図Dの位置を取る。これによりフォーク(8)により未処理のウェハー(47)が担持される。ついで、フォーク(8)はバッファ室(3)へと退却する。

第10図Dに示すように基板支持体(20)は更に下方へと移動する。この位置でゲートバルブが閉じられウェハー交換室(5)は大気圧にもどされる。そしてゲートバルブ(10)(13)が開けられる。

第10図Eの位置に基板支持体(20)が停止するとベルトコンベイ(57a)(57b)上に処理済のウェハー(47')が図示する如く載せられる。こゝでゲートバルブ(12)(13)が開かれているので処理済のウェハー(47')は開口(11a)を通りベルトコンベヤ(14)により移送されて、処理済のウェハーカセット(19)内に導入される。基板支持体(20)は更に下方へと移動し第10図Fの位置をとる。この位置ではベルトコンベヤ(12)(56a)(56b)は基板支持体(20)の上段支持部Uより上方に位置するものであるが、この位置で未処理のウェハーストックカセット(13)から取出されたウェハー(47)はベルトコンベヤ(12)により移送されて開口(14a)を通ってウェハー交換室(5)内に導びかれる。ついで基板支持体(20)は上方へと移動し再び第10図Aの位置を取る。即ちベルトコンベヤ(56a)(56b)(57a)(57b)は基板支持体(20)の下方に位置する。未処理のウェハー(47)は上段U上に載置される。こゝでゲートバルブ(10)(11)が閉じられ交換室(5)内は真空状態に排気される。ついで冒頭に述べた如くゲートバルブ(8)が開けられフォーク(8)がバッファ室(3)よりウェハー交換室(5)内に処理済のウェハー(47')を載せて第10図Aに示す位置に至る。以下、上述の操作を繰返す。

なお、以上の工程において処理済のウェハー(47')が下段支持部Dに載置されているときには基板支持体(20)の基板部(31)内には冷却水が循環しているので、これとの熱交換により処理済で熱いウェハー(47')は冷却される。これによりウェハー交換室内から大気へと搬出されるときには化学変化を殆んど受けることなく安定した状態でカセット(19)内に収めることができる。

以上本発明の実施例について説明したが、勿論、本発明はこれに限定されることなく本発明の技術的思想にもとづいて種々の変形が可能である。

例えば、以上の実施例では上段支持部(59)には未処理のウェハー(47)を載置し、下段支持部(59)には処理済のウェハー(47')を載置させるようにしたが、これ等の支持部の段数を更に増加し、これ等を2つのグループに分けて、一方のグループには未処理のウェハーをそれぞれ載置するようにし、また他方のグループには各々処理済のウェハーを載置するようにしてもよい。処理済のウェハー及び未処理のウェハーの搬入及び搬出はそれぞれ同期して行うようにすればよい。この場合、段数に応じて搬入搬出用のベルトコンベヤが必要であり、またバッファ室から交換室へのまたこの逆のウェハーの搬入搬出には複数のフォークが必要であるが、これ等のフォークを上下に一体化して同期させるようにしてもよい。

また以上の実施例では下段の処理済のウェハー
冷却し処理済ウェハーを
を支持する段は冷却するようにしたが、これにかえて上段の支持部に加熱手段を設け、この上に載置される未処理のウェハーを加熱するようにしてもよい。この加熱したウェハーをバッファ室(3)及び反応室(2a)又は(2b)に導入させるようにしてもよい。

更に、基板支持体(20)において上段支持部と下段支持部との間に熱絶縁材を介設させ、上段支持部には加熱手段を設け下段支持部には上記実施例と同様に冷却手段を設けるようにしてもよい。

また以上の実施例では基板支持体(20)の高さ位置は5つとしたが、更にこの数を増大させてそれぞれの高さの位置において上記ウェハーの搬入、搬出方法以外の方法により搬入搬出を行うようにしてもよい。この場合、搬入、搬出機構としてのベルトコンベヤ及びフォークのレベルも実施例のように一個所だけでなく、上下に複数、設けるようにしてもよい。また、搬入、搬出手段もフォークやベルトコンベヤに限定されることなく公知の種々の手段が適用可能である。また以上の実施例では処理済のウェハーと未処理のウェハーとを別々のゲートバルブを介して搬入、搬出するようにしているが、共通の一つのゲートバルブを介してこれを行なってもよい。

〔発明の効果〕

以上述べたように、本発明の真空槽内における基板交換機構に依れば、大気中の所定の位置へウ

ェハー交換室から処理済ウェハーを搬出及び大気中の所定の位置からウェハー交換室へウェハーを搬入する作業、さらにそれに伴うベント、排気作業を処理室で他のウェハーの処理を行っている間に平行して行うことが可能となり、処理室でのウェハー交換作業上要する時間を最小にすることが出来、生産性を一段と向上させる事が出来る。

4 図面の簡単な説明

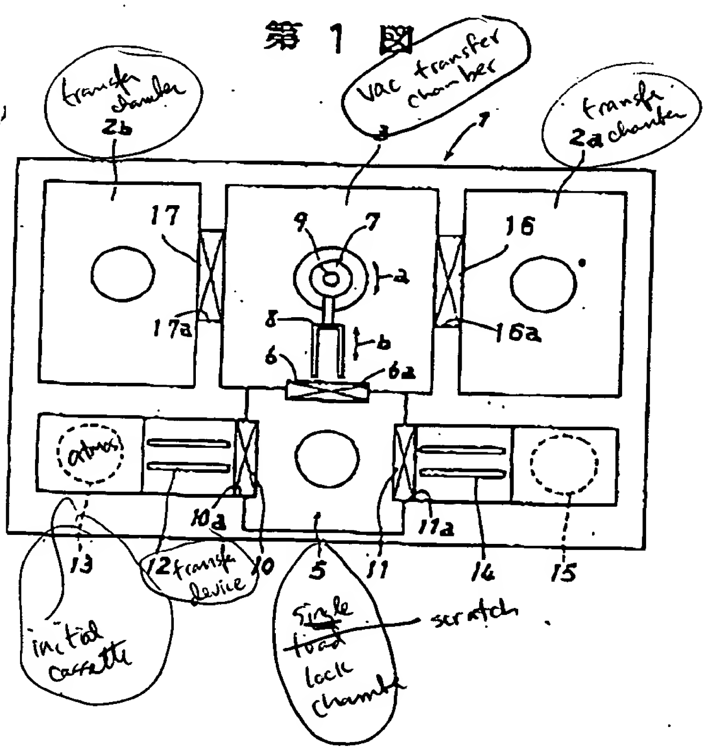
第1図は本発明の実施例に依るCVD装置全体の配置を示す平面図、第2図は上記装置に於ける基板交換機構の断面図、第3図は同基板交換機構に於けるゲートバルブの詳細を示す断面図、第4図は第3図に於ける一部分の斜視図、第5図は同基板交換機構に於ける基板支持体の拡大斜視図、第6図は同平面図、第7図は第6図に於けるⅦ－Ⅶ線方向断面図、第8図は第6図に於けるⅧ－Ⅷ線方向断面図、第9図は第6図に於けるⅨ－Ⅸ線方向断面図、~~第10図~~第10図A乃至Fは本実施例の作用を示すための要部の各側面図である。第11図は従来例の基板交換機構を示す断面図である。

尚、図において、

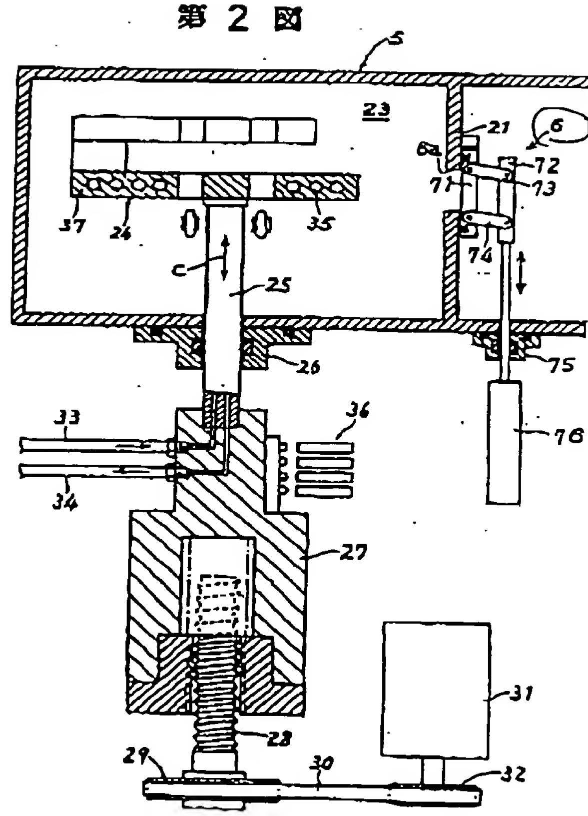
(5) ………… ウェハー交換室
(6) (10) (11) ………… ゲートバルブ
(20) ………… 基板支持体
(58) ………… 基板上段支持部
(59) ………… 基板下段支持部

代理人
飯阪泰雄

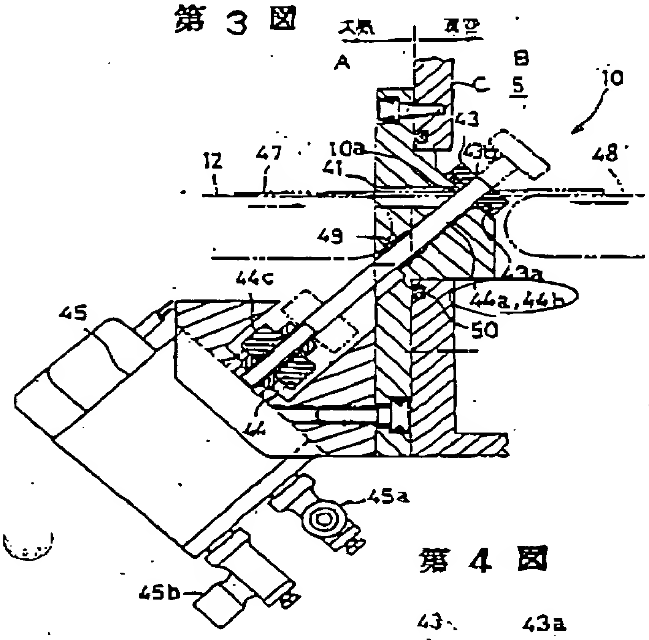
第1図



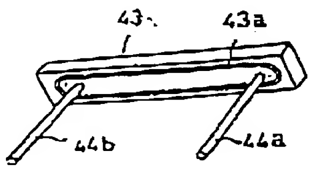

第2図



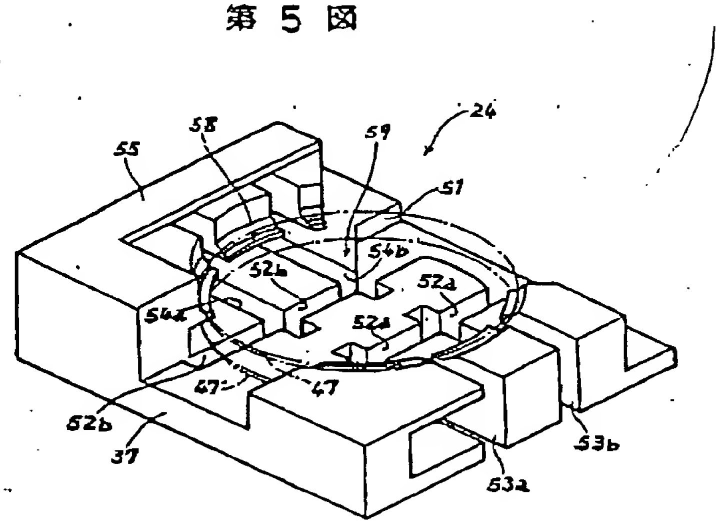
第3図



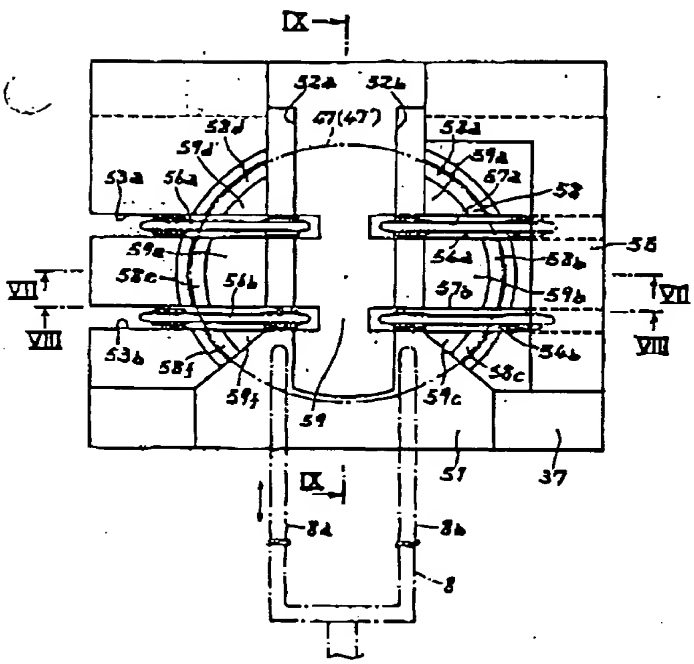
第4図



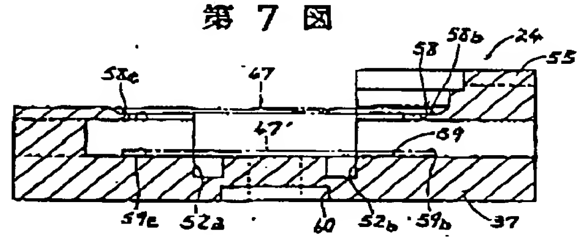
第5図



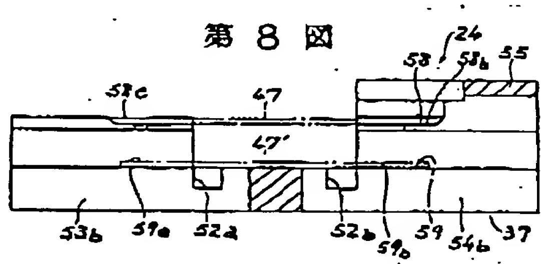
第6図



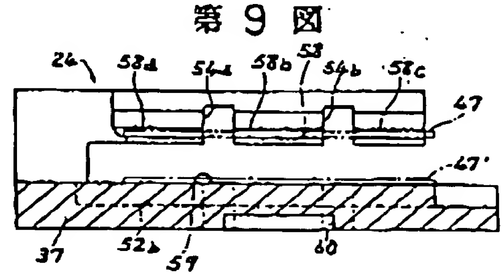
第7図



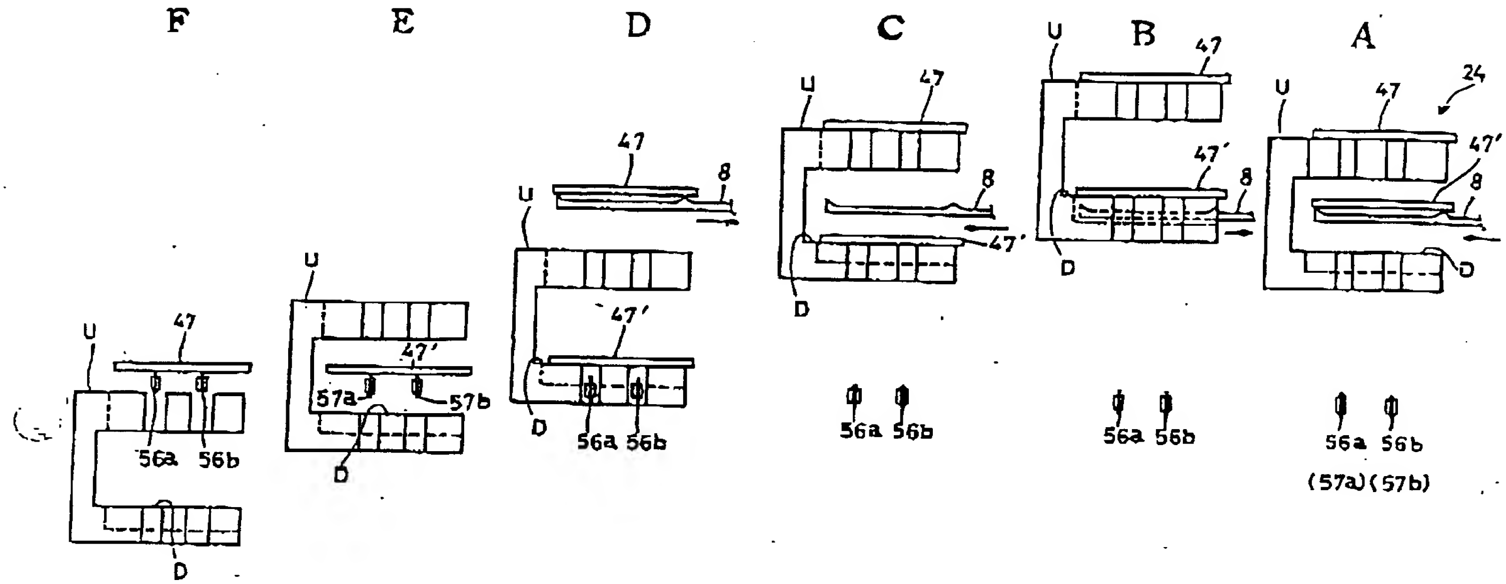
第8図



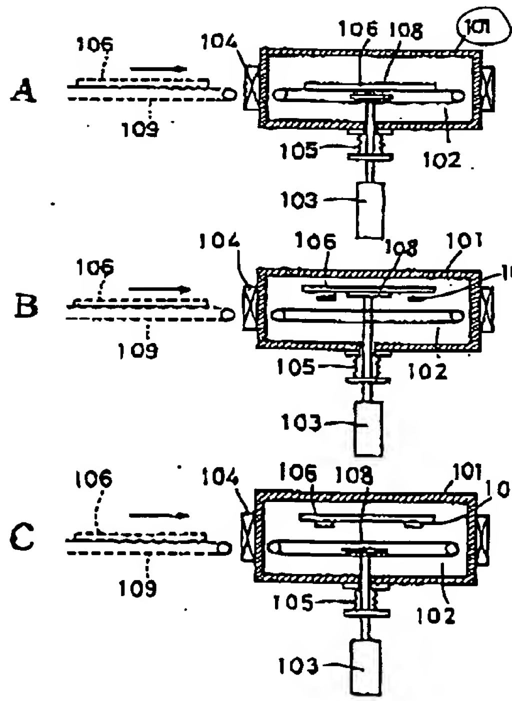
第9図



第10図


F
E
D
C
B
A
U
47
47'
8
24
D
56a
56b
57a
57b
(57a)(57b)

第11図


A
B
C
101
102
103
104
105
106
107
108
109

FULL TRANSLATION
OF JP 63-153270

Specification

1. Title of the Invention

Substrate Changing-Over Mechanism in Vacuum Tank

2. What is claimed is:

(1) A substrate changing-over mechanism within a vacuum tank, comprising:

a substrate supporting means arranged within the vacuum tank which has at least two openings at a side wall thereof, the openings being openable or closable by gate valves, said substrate supporting means having at least two stages of substrate supporting sections in upper and lower spaces; and

an ascending or descending driver section for driving said substrate supporting means in such a way that said substrate supporting means can be stopped in a vertical direction at a plurality of predetermined positions;

wherein a substrate of which surface has been processed can be mounted on one of said two stages, and a substrate not processed can be mounted on the other of said two stages.

(2) A substrate changing-over mechanism according to Claim 1, wherein one of said two stages is cooled.

(3) A substrate changing-over mechanism according to

Claim 1, wherein the other of said two stages is heated.

(4) A substrate changing-over mechanism according to Claim 1, wherein one gate valve of said both gate valves for performing communication with atmosphere and for shielding is configured in such a way that an opening, at the vacuum chamber, of through-pass holes arranged at the side wall of said vacuum tank is upwardly inclined, and a valve plate for opening or closing said opening is ascended or descended by a driving source arranged at an atmosphere side through a rod extended through a vacuum partition wall and obliquely drawn out toward atmosphere.

(5) A substrate changing-over mechanism according to Claim 4, wherein said valve plate is formed to be larger than a diameter of the substrate, and connected to a cylinder mounted at the atmosphere side through two rods fixed to both sides of the valve plate and drawn out to atmosphere.

3. Detailed Description of the Invention

[Industrial Field of the Invention]

This invention relates to a substrate changing-over mechanism in a vacuum tank.

[Prior Art and Its Technical Problem]

Fig. 11 shows one example of the prior art loading mechanism for taking a wafer from atmosphere into a vacuum tank. In this figure, this mechanism has a function in

which it is operated such that a wafer (106) fed into a vacuum tank (101) from the atmosphere into the vacuum tank (101) through a gate valve or a gate valve (104) by means such as a belt conveyer (109) is taken into an appropriate position within the tank (101) by a belt conveyer (102) arranged in the vacuum tank (101), this wafer is lifted up from the belt position by a wafer moving-up or -down mechanism separately arranged and then it is loaded onto another mechanism disposed below the wafer (106).

Now, the above-mentioned operation will be described in detail as follows. That is, as shown in Fig. 11A, the wafer (106) having its surface to be processed which is passed through the gate valve (104) from the atmosphere and fed into the vacuum tank (101) is further transferred up to an appropriate position by a belt conveyer (102) arranged within the vacuum tank (101) and stops there. Then, the gate valve (104) is closed and the inside of the vacuum tank (101) is evacuated into a vacuum state.

As shown in Fig. 11B, at the aforesaid time, a wafer pushing device (108) positioned below a position where the wafer (106) rides on the belt (102) is lifted up by the wafer moving-up or -down cylinder (103) while a vacuum sealing is being kept through a bellows (105) to lift up the wafer (106) more upwardly than the belt surface, and then another wafer transferring mechanism (107) (for

example, a pick-up of a fork transferring device) advances below the wafer (106).

Then, as shown in Fig. 11C, the wafer pushing device (108) descends and the wafer (106) is delivered onto another wafer transferring mechanism (107).

The foregoing relates to an operation in which the wafer (106) is taken into the vacuum tank (101) from the atmosphere, while in turn a procedure in which the processed wafer (106) is taken out to the atmosphere is performed in the order opposite to the former one. That is, in the case of the aforesaid example of the prior art, the wafer (106) already processed is transferred by the mechanism (7) into the vacuum tank (101) evacuated into vacuum, thereafter the vacuum tank (101) is ventilated and the processed wafer (106) is taken out. Further, the wafer (106) not yet processed is taken into the vacuum tank (101) to perform a vacuum evacuation, and thereafter it is transferred to a processing chamber by the mechanism (107). During a loading and an unloading of the wafer including the aforesaid evacuation cycle between atmosphere and vacuum, the processing chamber requires a waiting time, resulting in that its efficiency is poor.

In order to avoid this problem, although there is used a method in which a vacuum tank for loading the wafer and a vacuum tank for unloading the wafer are separately

arranged, this method causes a configuration of the device to be complicated.

In addition, in the case where there is provided only one vacuum tank, a fast evacuation and a fast ventilation are required to make a fast evacuating cycle between atmosphere and vacuum in a normal way although depending on a through-put of the device, a recent trend in which a pattern size of an LSI is made to be fine causes it to be essential that an adhesion of particle to the wafer is restricted as much as possible and so a fast evacuation or fast ventilation within the vacuum tank where a flying of particles may easily be produced is not preferable.

[Problems to be Solved by the Invention]

It is an object of the present invention to provide a substrate changing-over mechanism within a vacuum tank in which various kinds of disadvantages found in the prior art are overcome, a next wafer is loaded into the vacuum tank while the previous loaded wafer (substrate) is being processed in the processing chamber, and further the vacuum evacuation is already completed, whereby time required to perform ventilation and evacuation is omitted from the wafer changing-over work at the processing chamber, and a waiting time at the processing chamber is reduced to improve productivity.

[Means for Solving the Problems]

The aforesaid object is accomplished by a substrate changing-over mechanism within a vacuum tank, comprising: a substrate supporting means arranged within the vacuum tank which has at least two openings at a side wall thereof, the openings being openable or closable by gate valves, said substrate supporting means having at least two stages of substrate supporting sections in upper and lower spaces; and an ascending or descending driver section for driving said substrate supporting means in such a way that said substrate supporting means can be stopped in a vertical direction at a plurality of predetermined positions; wherein a substrate of which surface has been processed can be mounted on one of said two stages, and a substrate not processed can be mounted on the other of said two stages.

[Operation]

A processing in which the substrate already processed is mounted at one of the two upper and lower stages of the substrate supporting sections while the substrate not yet processed is being mounted is carried out under a vacuum state, then the substrate not yet processed is transferred to the required processing chamber under this state, after this operation, an inside part of the vacuum tank is changed into surrounding atmospheric pressure, the substrate not yet processed is transferred to said one substrate supporting section and the substrate

already processed is transferred to the desired location in the atmosphere. Then, the inside of the vacuum tank is evacuated and then the aforesaid operation is repeated.

In the aforesaid series of operation, the operation in which the inside part of the vacuum tank is set to the surrounding atmospheric pressure, the substrate not yet processed is loaded to one substrate supporting section, the substrate already processed is unloaded to the desired location in the atmosphere and further the inside part of the vacuum tank is evacuated is already completed while the substrate not yet processed transferred to the processing chamber is being processed.

[Preferred Embodiment]

Referring now to the drawings, a CVD device according to the preferred embodiment of the present invention will be described as follows.

Fig. 1 schematically shows a device (1) of the present invention, wherein there are provided a pair of right and left CVD reaction chambers (2a), (2b) and a buffer chamber (3) is arranged between these reaction chambers. A partition wall between the buffer chamber (3) and both reaction chambers (2a), (2b) is provided with gate valves (4a), (4b) and then loading or unloading of the wafer is carried out through these members. A wafer changing-over chamber (5) according to the present

invention is arranged in front of the buffer chamber (3) and loading or unloading of the wafer is carried out between these chambers (3), (5) through the gate valve (6).

A wafer transferring mechanism (7) is arranged within the buffer chamber (3). The wafer transferring mechanism (7) is provided with a transferring fork (8), it can be rotated around a central shaft (9) as indicated by an arrow (a) and can be extended or shrunk as indicated by an arrow (b). Both side walls of the wafer changing-over chamber (5) are also provided with gate valves (10), (11), a not processed wafer transferring belt (12) is provided on one side of the gate valves, one piece of wafer is automatically taken out from a wafer stock cassette (13) under a predetermined timing and then the wafer is loaded into the wafer changing-over chamber (5) by the belt (12). In turn, a processed wafer unloading belt (14) is provided on the other side and the wafer is loaded into the processed wafer stock cassette (15).

Then, referring now to Figs. 2 to 9, details of the wafer changing-over chamber (5) will be described.

As shown in Fig. 2, the wafer changing-over chamber (5) is defined by a closing tank (21), and as described above, both side walls are provided with gate valves (10), (11) (not shown in Fig. 2), the rear wall part is provided with a gate valve (8). Details of these gate valves (8),

(10), (11) will be described later. An inside part of the chamber (23) is sealingly closed under these closed state and the inner side of the chamber (23) is kept in vacuum or pressure reduced state by an evacuating mechanism not shown.

Within the chamber(23) is arranged a substrate supporting member (24) of which entire shape is clearly illustrated in Fig. 5, wherein a driving shaft (25) is fixed to the bottom surface of the substrate supporting member 24. The driving shaft 25 air-tightly passes through the bottom wall of the closed tank (21), extends into lower atmosphere and is fixed to a screw engaging member (27). The driving shaft (25) is air-tightly and slidably supported by a vacuum seal (26) in an upward or downward direction.

The screw engaging member (27) is threadably engaged with a ball screw (28), and a pulley (29) is fixed to the lower end of the screw (28). A motor (31) is fixed to a frame (not shown), and a belt (30) is wound and installed between the pulley (32) fixed to the rotating shaft and the aforesaid pulley (29). The ball screw (28) is rotated under rotation of the motor (31), whereby the screw engaging member (27) and the driving shaft (25) are moved in an upward or downward direction. The motor (31) can be freely rotated in a normal or reverse direction, and the driving shaft (25) is moved in an upward or downward

direction in response to this rotating direction. A height sensor device (36) is provided on one side of the screw engaging member (27), each of the height positions of the driving shaft (25) is detected by this sensor and then driving of the motor (31) is controlled by this sensed signal.

The ball screw (28) is made such that as known in the art a ball is fitted into a threaded groove and the driving shaft (25) can be lifted up or descended down accurately to a predetermined position without any backlash.

The screw engaging member (27) is formed with a cooling water inlet and a cooling water outlet port on a small diameter part thereof, and to each of the inlet and outlet ports is connected a cooling water feeding tube (33) and a cooling water feeding-out tube (34), respectively. Within the driving shaft (23) are formed a feeding passage and a discharging passage (not shown) and these passages are communicated with a circulating passage (35) formed in a zig-zag fashion within a base part (37) of the substrate supporting member (24). In addition, the substrate supporting member (24) is made of aluminum and has a superior thermal conductivity.

The gate valves (6), (10), (11) are arranged at three side walls of the closed tank (21) as described above, wherein it is constructed such that openings (6a), (10a),

(11a) formed at these side walls are air-tightly closed, this arrangement is schematically shown in Fig. 1. In Fig. 2, a detail of the gate valve (6) is illustrated.

Referring to Fig. 2, the gate valve (6) will be described at first, wherein this is a widely well-known structure. The gate valve (6) mainly comprises a gate main body (71) for opening or closing the opening (6a), and a driving member (72) connected to the gate main body with parallel links (73), (74), a lower end portion of the member (72) is protruded out to the atmosphere through a vacuum seal (75) and it is driven by a cylinder device (76) in an upward or downward direction. In Fig. 2, the gate main body (71) closes the opening (6a), wherein as the driving member (72) is descended, the gate main body (71) releases the opening (6a) and further as the driving member (73) is ascended, it may close the opening (6a) as shown in Fig. 2.

Next, details of the gate valves (10), (11) will be described as follows. Since the gate valves (10), (11) have the same configurations to each other, only the gate valve (10) will be described as follows in reference to Figs. 3 and 4. Fig. 3 is an essential sectional view for showing an operating state of the gate valve (10). A partition wall C for partitioning an atmospheric space A from a vacuum chamber B (the wafer changing-over chamber

(5) is formed with a through-pass hole (41), an opening (10a), at the vacuum chamber B, of the through-pass hole (41) is formed upwardly obliquely.

A valve plate (43) for opening or closing a valve seat formed around the opening (10a) is arranged in opposition to it. The valve plate (43) is formed to have a larger size than a diameter of the wafer (47) and connected to the hydraulic (hydraulic or pneumatic) driving cylinder (45) arranged below in the atmosphere space A through two rods (44a), (44b) (one of them is shown in Fig. 3) passed through the hole (41) and partition wall C at both sides and extending obliquely downwardly. As shown in Fig. 4, the aforesaid two rods (44a), (44b) are set such that their upper ends are fixed more inside than O-rings (43a) at both sides of the valve plate (43) are, and the rod and the valve plate are sealed with welding (43b) or the like so as not to generate any leakage from their connected portions. In addition, the lower end is connected to a piston rod (44) of a cylinder (45) through a connecting member (44c) connecting two rods. In the figure, reference numerals (45a), (45b) denote pressure fluid supplying or discharging conduits for the cylinder (45), and reference numerals (12), (48) denote transfer belts mounted at each of the surrounding atmospheric space A and the vacuum chamber B, reference numeral (49) denotes a bearing bushing and

reference numeral (50) denotes an O-ring.

Since the gate valves are configured as described above, during a normal state, i.e. when the wafer is not loaded the valve plate (43) sealingly closes the opening (42) at the vacuum chamber side of the through-pass hole (10a) of the partition wall C under a reversed pressure state, i.e. under a state in which a pressure (atmospheric pressure) is acted via the through-pass hole (10a) in a valve opening direction with the hydraulic pressure acting in a downward direction within the cylinder (45). Accordingly, the vacuum state in the vacuum chamber B is not leaked through the through-pass hole (10a).

Then, in the case where the wafer (47) fed from the surrounding atmospheric space A with the transfer belt (12) is transferred to the vacuum chamber B, the fluid passage in the cylinder (45) is changed over to cause the valve plate (43) to be lifted up through rods (44), (44a), (44b) and then the opening (42) is released. At this time, the through-pass hole (10a) is positioned at a middle part between the two rods (44a), (44b), so that no hindrance is produced against a passage of the wafer (47), and then the wafer is smoothly transferred to the vacuum chamber B.

Then, at the stage in which the wafer (47) is completely transferred into the vacuum chamber B, the flow passage in the cylinder (45) is changed over again and the

valve plate (43) is descended, resulting in that the opening (10a) is closed. In addition, the wafer (47) transferred into the vacuum chamber B is transferred by the transfer belt (48) up to a predetermined position of the substrate supporting member (24).

In accordance with the preferred embodiment, the driving source for operating the valve plate is arranged at the atmosphere side and all the sliding sections for use in operating the valve plate are located below the wafer, so that there occurs no possibility at all that dusts generated at the sliding sections drop onto the wafer. The vacuum chamber is not contaminated by the driving source, too. Further, since the valve plate and the rods are arranged while being inclined to the vacuum partition wall, so that they can be formed compact. Further, since both transfer belts for the wafer in both chambers can be arranged to be adjacent to each other, the device becomes compact and correspondingly its workability in operation is also improved. In addition, since the valve plate results in sealing the opening under the reverse pressure state against the pressure difference, it is necessary to select the valve plate having a sufficient rigidity and a cylinder (a driving source) having a sufficient thrust force.

In the aforesaid preferred embodiment, although it has been described about the structure in which the fluid

pressure driving cylinder is used as a driving source for the valve plate, it is of course apparent that the present invention is not limited to this embodiment, and it is also possible to replace it with a mechanical driving mechanism.

Next, referring now to Figs. 5 to 9, details of the substrate supporting member (24) will be described as follows.

A substrate part (37) of the substrate supporting member (24) is formed with a fork receiving recess (51) which is formed at a much lower level than this upper surface is, and a pair of grooves (52a), (52b) are formed in communication with the recess. In Fig. 6 is illustrated a part of the wafer transfer fork (8), and the fork sections (8a), (8b) can be inserted into the grooves (52a), (52b).

A pair of parallel recesses (53a), (53b) are formed over an entire height at a half part of the wafer loading side of the substrate supporting member (24) in a direction perpendicular to an extending direction of the grooves (52a), (52b) and a pair of parallel recesses (54a), (54b) are also formed at the half part of the wafer carrying out side while being aligned with the recesses (53a), (53b). However, as clearly shown in Figs. 6 and 8, one end of it is not covered over the entire height, but covered by the connecting section.

Belt conveyors (56a), (56b), (57a), (57b) are arranged in compliance with the recesses (53a), (53b), (54a), (54b) in a vertical direction and the belt conveyers can pass through the recesses (53a), (53b), (54a), (54b) when the substrate supporting member (24) is moved up and down. The belt conveyors (56a), (56b) entirely constitute the belt conveyor (48) shown in Fig. 3.

At the central upper part of the substrate supporting member (24) are formed a partial flange-shaped upper stage substrate supporting section (58) and a concentric partial circular-shaped lower stage supporting section (59). As clearly shown in Fig. 6, the upper stage substrate supporting section (58) is comprised of arc-shaped receiving surfaces (58a), (58b), (58c), (58d), (58e), (58f) and they are placed on the same level. However, as shown by a dotted line in Figs. 7 and 8, a not processed wafer (47) is mounted on the upper stage substrate supporting section (58) composed of these elements. In addition, the lower stage substrate supporting section (59) comprises receiving surfaces (59a), (59b), (59c), (59d), (59e), (59g) having the same level and constituting a part of circle, wherein as clearly indicated by a dotted line, the wafer (47)′ already processed at its surface is mounted on these elements.

Although a circular stepped hole recess (60) is

formed on the bottom surface of the substrate section (37), the upper end of the aforesaid driving shaft (25) is fitted in the recess and fixed with a screw not shown.

The foregoing has been described in reference to the preferred embodiment and its operation will be described as follows.

Figs. 10A to 10F illustrate each of height positions of the substrate supporting member (24) and in accordance with the preferred embodiment, the substrate supporting member (24) can take five kinds of height positions. Both a level of the fork (8) extended out of or shrunk from the buffer chamber (3) and a level of each of the belt conveyors (56a), (56b), (57a), (57b) are kept constant. A shape of the substrate supporting member (24) in Fig. 10 is shown in its simplified form, and the aforesaid upper stage supporting section (58) and the lower stage supporting section (59) for the wafer are shown in the turned U-shaped upper arm and the turned U-shaped lower arm in order to facilitate an illustration of the figure, wherein they are denoted by U or D, respectively. (That is, U and D are equivalent for the upper stage supporting section (58) and the lower stage supporting section (59).) It is now assumed that the substrate supporting member (24) is placed at the height position shown in Fig. 10A and the not processed wafer (47) is mounted on the upper stage

supporting section U. Further, it is assumed that the gate valves (10), (11) at both side walls are closed. (The gate valve (6) is opened and kept under a vacuum state.) Under this state, the fork (8) extends from the buffer chamber (3) to mount the processed wafer (47)′ and reaches a location between the upper stage supporting section U and the lower stage supporting section D as shown in Fig. 10A.

In this case, the substrate supporting member (24) ascends to the position shown in Fig. 10B. During this ascending operation, the processed wafer (47)′ is mounted on the lower stage supporting section D, and stops there. Although the substrate supporting section (24) ascends and stops at a position shown at a position in Fig. 10B, the fork (8) in this case is apart from the processed wafer (47)′ and is kept at the illustrated position (within the grooves (52a), (52b)). At this position, the fork (8) retracts toward the buffer chamber (3) as indicated by an arrow.

As shown in Fig. 10C, the substrate supporting member (24) descends and again occupies the same position as that of the height shown in Fig. 10A. Then, the fork (8) extends from the buffer chamber (3) into the wafer changing-over chamber (5) as indicated by an arrow in Fig. 10C and occupies the position shown in the figure. The substrate supporting member (24) is moved in a downward

direction and occupies the position shown in Fig. 10D. Thus, the not processed wafer (47) is carried by the fork (8). Then, the fork (8) returns back to the buffer chamber (3).

As shown in Fig. 10E, the substrate supporting member (24) is further moved in a downward direction. At this position, the gate valve is closed and the wafer changing-over chamber (5) is returned back the state kept at surrounding atmospheric pressure. Then, the gate valves (10), (11) are opened.

As the substrate supporting member (24) is stopped at the position indicated in Fig. 10B, the processed wafer (47)' is mounted on the conveyer belts (57a), (57b) as shown in the drawing. In this case, since the gate valves (10), (11) are opened, the processed wafer (47)' passes through the opening (11a), is transferred by the belt conveyor (14) and fed into a processed wafer cassette (15). The substrate supporting member (24) is further moved in a downward direction, and occupies the location shown in Fig. 10F. At this position, the belt conveyors (12), (56a), (56b) are located more upwardly than the upper stage supporting section U of the substrate supporting member (24). However, the wafer (47) taken out of the wafer stock cassette (13) for not processed wafer in that position is transferred by the belt conveyor (12), passes through an

opening (14a) and is guided into the wafer changing-over chamber (5). Then, the substrate supporting member (24) is moved upwardly, and occupies the position shown in Fig. 10A. That is, the belt conveyors (56a), (56b), (57a), (57b) are positioned below the substrate supporting member (24). The not processed wafer (47) is mounted on the upper stage U. In this case, the gate valves (10), (11) are closed and the inner side of the changing-over chamber (5) is evacuated to a vacuum state. As already described above, the gate valve (6) is opened and then the fork (8) reaches to the position shown in Fig. 10A from the buffer chamber (3) into the buffer changing-over chamber (5) while mounting the processed wafer (47)′ on it. After that, the aforesaid operation is repeated as follows.

In the case of the aforesaid steps, when the processed wafer (47)′ is mounted at the lower stage supporting section D, cooling water is being circulated within the substrate section (37) of the substrate supporting member (24), so that the processed hot wafer (47)′ is cooled through a heat exchanging with the cooling water. With such an arrangement as above, when the wafer is transferred out of the wafer changing-over chamber to the atmosphere, the wafer is scarcely subjected to any chemical change and the wafer can be stored within the cassette (15) under a stable state.

Although the preferred embodiment of the present invention has been described above, it is of course apparent that the present invention is not limited to this embodiment, but various kinds of modification can be carried out in response to a technical concept of the present invention.

For example, in the case of the aforesaid preferred embodiment of the present invention, although the not processed wafer (47) is mounted on the upper stage supporting section (58) and the processed wafer (47)' is mounted on the lower stage supporting section (59), it may also be applicable that the number of steps of these supporting sections is increased, they are classified into two groups, each of the not processed wafers is mounted in one group of the supporting sections and each of the processed wafers is mounted in the other group. Each of the loading or unloading of the processed wafer and the not processed wafer is carried out in a synchronous manner. In this case, although a loading or unloading belt conveyor is required in response to the number of steps, a plurality of forks are required for loading or unloading of the wafer from the buffer chamber to the changing-over chamber or in turn from the changing-over chamber to the buffer chamber, it may also be applicable that these forks are integrally assembled in an upward or downward direction to perform a

synchronous operation.

In addition, although the lower stage for supporting the processed wafer is cooled to cool the processed wafer in the aforesaid preferred embodiment, it is also applicable that a heating means is arranged at the upper stage supporting section in place of it to heat the not processed wafer mounted on the supporting section. It is also applicable that this heated wafer is loaded into the buffer chamber (3) and the reaction chamber (2a), or (2b).

In addition, it may also be applicable that a thermal insulating material is placed between the upper stage supporting section and the lower stage supporting section of the substrate supporting member (24), the upper stage supporting section is provided with a heating means and the lower stage supporting section is provided with a cooling means in the same manner as that found in the aforesaid preferred embodiment.

In the aforesaid preferred embodiment, there are provided five kinds of height position of the substrate supporting member (24), although this number is increased further to perform the loading or unloading of the aforesaid wafer at each of the height positions by another method other than the aforesaid loading and unloading methods for the wafer. In this case, the number of belt conveyors and the forks acting as the loading or unloading

mechanism is not limited to one, but a plurality of conveyors or forks can be arranged. In addition, the loading or unloading means is not limited to the fork or belt conveyor, but various kinds of known means can be applied. In the aforesaid preferred embodiment, although the processed wafer and the not processed wafer are loaded or unloaded separately through a separate gate valve, these operations may be carried out through one common gate valve.

[Effect of the invention]

As described above, in accordance with the substrate changing-over mechanism placed in the vacuum tank of the present invention, it becomes possible to perform an unloading operation for transferring the processed wafer from the wafer changing-over chamber to the predetermined position in the atmosphere, a loading operation for inputting the wafer from the predetermined position in the atmosphere to the wafer changing-over chamber, a ventilating operation and an evacuating operation accompanied with the former unloading or unloading operation in synchronization with another processing of the wafer at the processing chamber, as a result of which a time required for performing the wafer changing-over operation at the processing chamber can be minimized and its productivity can be improved more.

4. Brief Description of the Drawings

Fig. 1 is a top plan view for showing an entire arrangement of a CVD device in accordance with the preferred embodiment of the present invention.

Fig. 2 is a sectional view for showing a substrate changing-over mechanism in the aforesaid device.

Fig. 3 is a sectional view for showing a detail of a gate valve in the substrate changing-over mechanism.

Fig. 4 is a perspective view for showing a part in Fig. 3.

Fig. 5 is an enlarged perspective view for showing a substrate supporting member in the substrate changing-over mechanism.

Fig. 6 is a top plan view of Fig. 5.

Fig. 7 is a sectional view taken along line VII-VII in Fig. 6.

Fig. 8 is a sectional view taken along line VIII-VIII in Fig. 6.

Fig. 9 is a sectional view taken along line IX-IX in Fig. 6.

Figs. 10A to 10F are side elevational views for showing each of substantial portions to indicate an action of the preferred embodiment of the present invention.

Fig. 11 is a sectional view for showing a substrate changing-over mechanism in the prior art.

In the figures:

(5) … wafer changing-over chamber

(6) (10) (11) … gate valve

(21) … substrate supporting member

(58) … substrate upper stage supporting section

(59) … substrate lower stage supporting section